ANALYSIS OF ELECTRIC VEHICLES FOR IMPROVED VEHICLE PERFORMANCE AND ASSOCIATED COST

SHORT SYNOPSIS

Submitted in partial fulfillment of the requirement of the degree of

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by

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Certificate

I hereby declare that the short synopsis "Analysis of Electric Vehicles for improved vehicle performance and associated cost" being submitted in partial fulfillment of the requirement for the degree of Doctor of Philosophy in Automobile Engineering under faculty of Engineering and Technology of Manav Rachna International Institute of Research & Studies, Faridabad during the academic year 2022-23. It is a bona fide record of original work carried out under the supervision of Prof. (Dr.) Devendra Vashist and has not been submitted in full or part to any other university or institute for degree or diploma. Further, it is certified that short synopsis is plagiarism free and proof has been submitted.

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ABSTRACT

The humans are becoming more and more dependent on the technology which enhance energy consumption from fuels, as a result, pollution and global warming are increasing, which is posing a great threat to the environment. For about three decades, government authorities have been trying to control pollution levels by framing emission standards for mobility Industry. Govt agencies are also continuous and timely making changes in the Bharat Standards for reducing emission levels to zero by technology enhancement. But with this continuous amendment in the policies relating to pollution there is still a risk of depletion of non-renewable fossil fuels.

The fossil fuels are not only getting exhausted, but also emits numerous forms of pollutants in the environment while being used in vehicles. To mitigate this problem the best solution that serves for protection of environment and also on the other hand, ensures the safeguard of existing natural fossil fuels is the use of vehicles with electrified powertrain. Such vehicles may or may not include the use of fossil fuels. These electric vehicles have a number of advantages as compared to the popular conventional fuel cars like low Noise-Vibration and Harshness, low emissions and higher efficiency. As Electric Vehicles (EVs) penetration in the market, there is a lot to understand related to performance of EVs subcomponents.

Literature was done for understanding the present state of research undergoing in the present area. The review was classified based on the specific area covered. The fields were, electric vehicle battery chemistry, electric vehicle safety and standards, electric vehicle dynamics, EV drive cycle, financial impact for transition to electric mobility, EV simulation analysis. Based on the review research gaps were identified that includes examining new battery material combination in Indian context, safety concerns, vehicle dynamics and thermal aspects of batteries, EV driving pattern with respect to Indian conditions, financial cost implications while shifting to EV based mobility and simulation analysis for safety and commercial viability.

Selection of an electric vehicle will be made based on commercial and technical market driven factors / parameters, that includes specific energy, energy density, specific power, typical voltages, amp hour efficiency, energy efficiency, commercial availability, cost, operating temperatures, self-discharge rates, number of life cycles, recharge rates of the batteries. An understanding how energy availability varies with regard to ambient temperature, charge and discharge rates, battery geometry, optimum temperature, charging methods, cooling needs, vehicle dynamics and material varies with changing vehicle environment will be a part of study. A suitable battery system for power supply as per the demand will be selected. Calculations based on EV dynamics for the selected vehicle will be made by using IDC (Indian Drive Cycle). Simulation of the EV will be performed and the results will be compared with the field values. A mathematical tool will be used to interpret the findings. The analysis of variance (ANNOVA) will be used statically to interpret and analyze the results. Further a mathematical model will be developed for significant influential parameters effecting the performance of EVs. Based on the analysis of results a set of optimal process parameters will be calculated for the selected design of EV.

Keywords: Electric Vehicle, Pollution, Electric Powertrain, Motor, Battery

CONTENTS

S. No	Description	Page No
a.	Certificate	ii
b.	Abstract	iii
c.	Contents	iv
1.	Introduction	1
2.	Literature Review	4
3.	Description of Broad Area	9
4.	Research Gap from Literature Review	10
5.	Objectives of the Study	10
6.	Proposed Research Methodology	12
7.	Expected Outcome of the Research	14
8.	Proposed Work Plan and Scheduling	14
	References	16

1. Introduction

Advanced technology has reduced the physical human intervention and has increased the living comfort of human beings. These technologies require energy for smooth operation. Most of this energy comes from non-renewable energy sources. When these sources are utilized, emissions in the form of gaseous products are released in the environment as pollution. This increased level of pollution is the root cause of climate change. There have been numerous efforts by the National Green Tribunal, State Governments and Central Government collectively to protect the sanctity of the nature, by protecting environment. Shifting from conventional fuel-based mobility to renewable energy supported electric mobility is one such initiative that has been eagerly pursued by governments and policy makers.

A study done by World Health organization in 2016 showed that Delhi is world's most polluted city. A comparative figure with major cities of the world is shown in figure 1. **Organization, (2016).** One of the results of the study indicates that effect of this increased pollution resulted in more than twenty lakh deaths due to lung diseases.

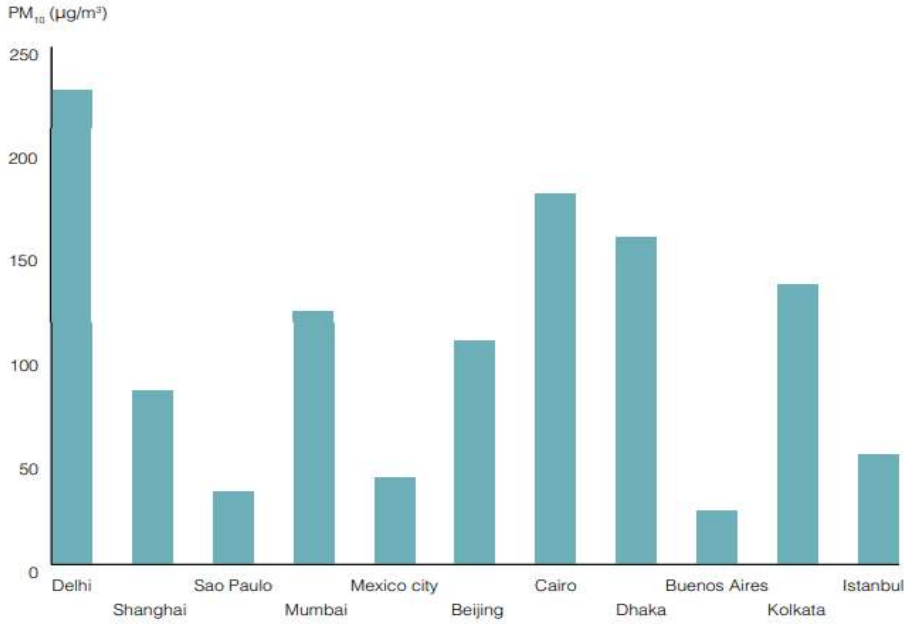


Figure 1: Data taken by WHO regarding Particulate matter (less than 10 microns)(Organization, 2016)

According to an analysis of pollution inventory by CEEW (Council on Energy, Environment and Water) for $PM_{2.5}$ and PM_{10} (as given in Table 1), **[Inventories, (2019)]** the transport sector is responsible for emitting highest percentage of particulate matter in the air. The survey also claims that the variation in inventory of emission is highest by transportation and has been presented in figure 2.

Table -1. Survey on Emission Inventory by CEEW, 2019 **[Inventories, (2019)]**

Sector	Variation in PM_{10}%	Variation in $PM_{2.5}$%
Vehicles	6-19	18-39
Manufacturing	1-18	2-29
Power Plants	2-17	3-11
Dust on Road	36-66	18-38
Construction	4-21	2-8

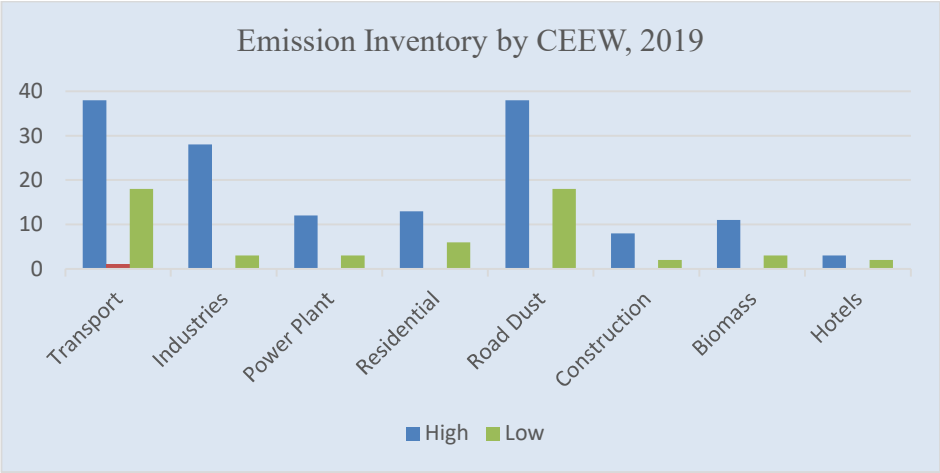


Figure 2: Emission Inventory by CEEW, 2019 [Inventories, (2019)]

Therefore, there is a dire need to lower down these transportation emissions. In the metro cities of India a number of variety of vehicles ply. Some researchers has classified them in seven types **[Tiwari, (2013)]**. Of these, motorized vehicle shares the largest chunk. The two-wheelers account for 64% occupancy as per the study made by economy survey [**'Economy survey of Delhi 2018-19.pdf' (2019)].** The graph shown in Figure 3 presents the different motorized vehicles on Delhi's roads in 2018.

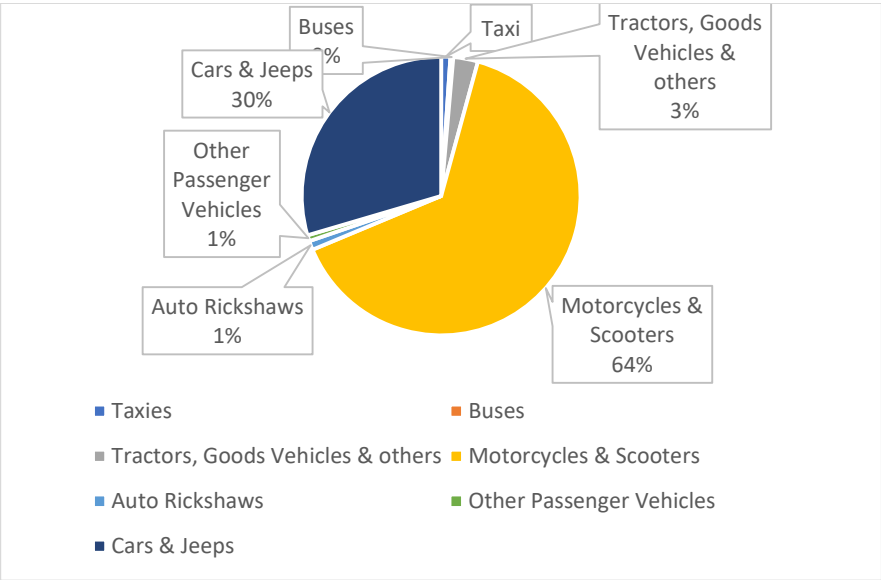


Figure 3: Motorized Vehicles on the roads of Delhi in 2018 ['Economy survey of Delhi 2018-19.pdf'(2019)]

In one of the research done in this area by Vidhi et.al in 2018 **[Vidhi and Shrivastava, (2018)]** indicated that vehicles used for goods purpose are the most polluting ones, followed by four-vehicles. The Buses are even lesser polluting than the personal two-wheelers. The results of the study is presented in the table 2.

Table 2: Vehicles and their corresponding emissions **(Vidhi and Shrivastava, 2018)**

Automobile	Carbon Dioxide	Carbon Monoxide	Hydro carbons	Particulate Matter	Oxides of Nitrogen	Sulphur Dioxide	VOC	Pb
4-wheeler	Peak	Moderate	Low	Low	Low	Moderate	Peak	Peak
2-wheeler	Moderate	Peak	Peak	Peak	Low	Moderate	Peak	Peak
Light Motor Vehicle	Low	Low	Low	Low	Low	Low	Low	Low
Heavy Motorized Vehicle	Low	Low	Low	Low	Low	Low	Low	Low
Goods Vehicle	High	Moderate	Low	Moderate	Peak	Peak	Low	Low

Researchers are continuously working in the field to find a solution for this existing problem. One of the solutions is to reduces the emission level by using new innovations in the technology. In one of the research "A review on energy, environment, and emissions issues in Indian road transport sector" **Agarwal *et al.*, (2021).** proposed the following techniques to reduce vehicular emission as shown in table 3.

Table 3: Techniques to reduce Emission **[Agarwal *et al.*, (2021)]**

S.No	Technology	Processing	Description	Costing
1	Engine	Down-sizing	Down-sizing the engine for its configurations, with the same power	Nil
2	Engine	Down-speeding	Down-speeding with the same power	Nil
3	Turbocharging	Two-stage Turbocharging	Advances Turbocharging for lower emissions	Investment required for implementation of Imported Technology
4	Advanced Controls	Advanced Controls for with sensors	Sensors and ECU's provide better control options	Low cost electronics research and development requires initial investment
5	EGR	Engine Gas Recirculation	EGR lowers NO_x	Nil
6	Alternate Fuels	Alternate Fuels use CNG, Ethanol, Biodiesel, etc	Alternate Fuels reduce Carbon Monoxide and other hydrocarbons, thereby lowering running cost and increasing efficiency	Investment required for development of adaptable combustion systems
7	Hybridization	Using a hybrid of Engine and Motor	Using Engine and Motor for same engine power	High investment for implementation of technology

In India, Vikram Safa was the first electric vehicle which was introduced in India. It was a three-wheeler introduced by Scooters India Pvt Ltd, a company based in Lucknow. It incorporated a 72-volt battery using the lead acid concept. Later Bijlee was introduced in 1999 by Mahindra and Mahindra Ltd.

In 2001, Reva Electric Car Company Ltd, with Founder Chetan Maini, from Bangalore, entered the EV sector in the car industry with a vehicle developed in association with American company Amerigon. Company Toyota introduced Prius, which was a hybrid of electric and gasoline, while in in 2013, Toyota introduced another vehicle Camry.

Though the implementation of technology could be different, but in order to survive with the growing pollution, as well as to keep the fossil fuels intact, there is a dire need to adopt electric vehicles **[Ribberink and Entchev, (2013)].**

2. Literature Review

A lot of efforts have been made by researchers all over the world to increase electric vehicle adoption with the help of improved design and technology. Numerous automotive industries are working in the present field to increase their customer base so that the transition to EV is self-driven rather than with the support of external agencies. A literature was done for understanding the present state of research undergoing in the present area. Based on the study and further analysis, the literature review is divided into six parts:

a. Electric Vehicle Battery Chemistry
b. Electric Vehicle Safety and Standards
c. Electric Vehicle dynamics.
d. EV Drive Cycle.
e. Financial Impact for transition to Electric Mobility
f. EV Simulation Analysis.

a. EV battery Chemistry

Battery is a device that converts chemical energy which is stored in it into the required electrical energy. The chemical reaction that takes place for the conversion process is called electrochemical reaction, and the battery is called electrochemical cell. It has a negative as well as a positive electrode. Negative electrode is called anode, and its function is to release electrons during electrochemical reaction, whereas positive electrode is called cathode and it accepts electrons during the process. The most used battery chemistries are Lead Acid, Nickel, Zinc-Halo, Sodium-beta, and Lithium-ion chemistries.

Sivaramaiah and Subramanian, (1992) in their study explained that lead acid batteries are intensively used in IC Engines, but attributing to their low energy density (in range of 30 $Whkg^{-1}$) the batteries are unsuitable for use in electric vehicle application.

Chau, Wong and Chan, (1999) concluded in their study that nickel batteries have high initial and maintenance cost, lower power and life cycle as compared to their counterparts. These drawbacks discourage them for usage in electric vehicles.

Chau, Wong and Chan, (1999); Manla *et al.*, 2009; Atwater and Dobley, 2011; Lai *et al.*, (2013) studied Zinc-Halo chemistries and concluded that these batteries are suitable for use in electric vehicle because of its fast-charging properties, less manufacturing cost and high specific energy (in the range of 70 Wh/kg).

Akhil *et al.*, (2013) in their study concluded that Sodium-beta batteries are cheaper than the batteries based on the other chemistries. Other characteristics that make them favorable for usage in EVs is its high temperature usage upto 300-350 degree.

Dincer and Rosen, 2002; Zhang *et al.*, (2014), worked on Na-ion chemistries for EV application. They concluded that such promising chemistries are suitable in EV application because of high energy, and power density.

Atwater and Dobley, (2011), while working analyzed that best part of these battery material is long life in the range of 4500 cycles [**Lee *et al.*, (2013) & ECOFYS, (2014)]**, and high energy

efficiency of about 85-90%. [**Chen *et al.*, (2009); Atwater and Dobley, (2011); Cotterman, (2013); Zhou *et al.*, (2013)].**

Akhil *et al.*, (2013); Tie and Tan, (2013), mentioned Lithium batteries are the most frequently utilized batteries for electric vehicles attributing to its super-light-weight, more energy density, high power and high specific energy, no memory effect and completely environment friendly behavior.

However, it's worth mentioning that according to **Hoque, Hannan and Mohamed, (2016); Sun, Liu and Cui, (2016),** Li-batteries are the most-costly batteries in their category, whereas, **Atwater and Dobley, (2011); Lv *et al.*, (2015)** explained that these batteries are advantageous, as these can withstand temperatures of up to 375 degrees Celsius.

b. EV Safety and standards

Government of India is promoting Electric vehicle in India by introduction of Automotive Mission Plan, National Electric Mobility Mission Plan. In this direction, ARAI is setting up Indian standards for electric vehicles, called Automotive Industry Standards. These standards outline in table 4:

Table 4: AIS Codes for standards

AIS Code	Standards
AIS-038	This standard deals with EV Power-train, and safety requirements. [**AIS-038, (2019**)]
AIS-039	The Energy consumption and its allied calculations are done in this standard. [**AIS-039, (2015**)]
AIS-040	The performance and range calculations are undertaken in this standard. [**AIS-040, (2015**)]
AIS-041	It deals with the power characteristics of electric motor. [**AIS-041, (2015**)]
AIS-049	EV – type in accordance with Central Motor Vehicles Rules is undertaken in this standard. [**AIS-049, (2016**)]
AIS-123	EV Propulsion Kit (for conversion to pure electric vehicle) approvals are dealt in this standard. [**AIS-123, (2019**)]
AIS-102	EV Propulsion Kit (for conversion to hybrid electric vehicle) approvals are undertaken in this standard. [**AIS-102, (2014**)]

Harikumar and Thakur, (2020), in their study concluded that Indian Government is popularizing electric mobility through FAME (Faster Adoption and Manufacturing of Hybrid and Electric vehicle), which was introduced in two phases. In FAME, the production of Hybrid and Electric vehicles will be provided with huge subsides in order to promote them.

Pedersen *et al.*, (2012). in their study analyzed the batteries and associated risks the research findings indicates that batteries see a lot of challenges like high capacity for longer distance of travel, high energy capacity, high energy density, greater power, etc while taking care of these requirements batteries are often exposed to shocks, heat, noise and vibration which if not controlled may lead to accidents.

Batteries for Electric Cars, **(2020)** report suggest that a proper standardization has to be required where in safety of the driver is not compromised. Also required is an infrastructure to manage power, charging, discharging and temperature difference. This management is called Battery management System

Hao *et al.*, (2018) in their study concluded that EVs overcrowded assembly of batteries store high amount of power. This power has to be stored within reasonable limits. Management of this high temperature is done with the help of set standards. These standards are to be carefully implemented by the industry.

c. EV dynamics

There are mainly three forces that act on an Electric Vehicle namely aerodynamic force, gradient and rolling resistance.

Liu, Yamamoto and Morikawa, (2017) describes Vehicle dynamics as a combination of certain resistances which influence the vehicle movement on a road namely friction (between tire and road), aerodynamic drag and gradient resistance.

Grunditz, (2016) studied vehicle loading characteristics and concluded that was an essential part to design powertrain. The study further suggested that vehicle performance is greatly affected during any sort of acceleration, turning, etc. This makes it important to study the loads that are acting on a vehicle, along with its subsequent directions.

Kiyakli and Solmaz, (2018) highlighted Aerodynamic drag and rolling resistance as two more major resistive forces. To maintain a constant speed, the net tractive force must completely match the net resistive force. In other words, a vehicle accelerates when the total tractive forces exceed the total resistive forces, and decelerates when the converse is true **Hoffmann and Werner, (2015).**

A motor consists of a magnetised rotor and a wound stator that is powered by a three-phase AC voltage source. Laminated steel plates serve as magnetic flux conduction channels in both the stator core and rotor.

d. **Analysis of EV Drive Cycle, driving pattern, with Indian Perspective.**

In order to analyze driving pattern in a particular geo-location, the speed vs time trend is analyzed in the particular environment. This trend is called drive cycle. Drive cycle depends upon a number of factors namely traffic conditions, weather, street condition, vehicle condition and driving pattern **Parekh and Shah, (2015).** Hence, considering all these conditions, it is challenge to optimize and standardize a particular drive cycle.

S. Sinha, (2013) mentioned that different countries have different standard driving cycles, such as the ECE-15, EUDC, and EPA Federal Test, according to him. These drive cycle data are used to calculate HEV component sizes and analyse car emissions.

Kamble, Mathew and Sharma, (2009) added that normal drive cycles conceal information such as rate of acceleration and deceleration, as well as power, peak power usage, and real trip duration. A typical drive cycle's data and analysis cannot be used to create efficient and cost-effective HEV components. The load pattern has an impact on the motor, IC engine, and battery architecture.

Because different countries have different driving cycles, India's road driving cycle must be captured in real time for obtaining reliable data, as real-time drive cycle data is necessary to analyse and offer significant information on drive cycle load patterns.

Shah, (2011) explained that real-time drive cycle measurement considers the natural environmental conditions of all types of roads, as well as various types of road conditions and traffic conditions, resulting in different drive cycles for different roads that can be used to estimate the size of HEV components.

e. Financial Impact for transition to Electric Mobility

The financial impact for transition from conventional to electric Vehicle technology is analyzed through three heads:

i. Personal Cost of Ownership
ii. Public Transport
iii. Charging Infrastructure

Personal Cost of Ownership:

Owning a Personal electric Vehicle has the following implications: **Singh *et al.*, (2021**) found out that though government of India introduced hefty subsidies on electric vehicles, but Indian gentry is still reluctant to purchase it because of its high cost, which is attributed to the imported batteries.

State Bank of India, (2020) notified that the interest rates for normal Gasoline fueled cars is 9.5%, whereas the electric vehicle counterpart is 0.2% lower. Also **Prashant Singh, (2020**) writes that these vehicles are free of loan processing charges which is 0.5% for gasoline vehicles.

Singla and Bansal, (2021) calculated the cost of running Tata Nexon. The cost of travel with gasoline was more than Rs.6/- per km, whereas the electric vehicle variant of the same car costed less than Rs.2/- per km. They concluded that it saves more than twice of the cost. **Nexon Petrol Maintenance, (2020**) costs about Rs.0.45/- per km, whereas on the contrary (Nexon EX Maintenance, 2020) costs Rs.0.35/- per km.

Kumar and Chakrabarty, (2020) suggested that policymakers must look for more viable solutions to lower down the initial cost of ownership, in order to promote Electric vehicle ownership.

Public Transport:

The first challenge in public transport is the available system of road transport. **Dash Dipak, (2018**) writes, Indian roads need 30 lakh buses in order to serve daily commuters, whereas the available number is only 19 lakh, of which 2.8 lakh buses only are run my State Transport undertakings, while others are privatized. Hence, to overcome this shortfall, a considerable investment will be required to be invested in the public domain.

Charging Infrastructure:

This is the most difficult public-domain challenge. As the number of electric vehicles grows, so will charging infrastructure and its demand. According to **Sharma Shalini, (2020)**, India had less than 500 electric vehicle charging stations in 2016, concentrated in major cities such as Mumbai, Bengaluru, Delhi, and Kolkata, but this number climbed to 993 in 2017, reports **Bureau, (2018).** Based on Bureau's report, with 30% electric vehicle penetration rate among a billion car population,

the it is estimated that India will require 3,00,000 high-speed charging stations by the end of 2030. And it's possible that this will invite an investment of Rs.11,000 Crore.

f. Simulation analysis of Electric Two-wheeler (ETW)

For designing and testing, a prototype is the first step of the product, which can cost several lack Rupees. And the worst part is, that it can either fail during testing, or may not fetch the desired results. Another alternative to designing a prototype is to design a virtual model in simulation tool and running the desired testing on the model. Some such tools are:

Marr and Walsh, (1992) developed a model MARVEL at Argonne National Laboratory, in order to simulate parameters of Battery Electric Vehicles, Heat Engine and Hybrid Electric Vehicle. MARVEL later incorporated default data sets of various existing vehicles, along with battery specifications for analysis.

Bumby JR, (1985) at Durham University modelled a simulation tool Janus, to simulate electric and hybrid vehicles. This resulted in obtaining their energy efficiency and related performance characteristics.

Benekohal RF, (1988) in association with Michigan university designed CarSim initially for normal traffic conditions. Then this tool was updates with Car dynamics features like control and performance.

Wipke and Cuddy, (1996) at National Renewable Energy Laboratory developed a model named ADVISOR, and incorporated an open programming environment on MATLAB platform. Simulation analysis of different combination of configurations were done through ADVISOR.

Butler, Ehsani and Kamath, (1999) used a tool V-Elph 2.01 developed by Texas A&M University, and designed a vehicle model to simulate vehicle emissions.

Auert et al., (1998) developed a tool which was capable of analyzing the electro-mechanical behavior of hybrid vehicles

Sri Kaloko, Soebagio and Hery Purnomo, (2011) designed a MATLAB model of eV and ran simulations to analyze battery capacity and other specifications, to match or achieve a certain distance.

Husain and Islam, (1999) designed a MATLAB eV model incorporating a switched reluctance motor drive, and simulated parameters related to motor, battery, controller and drivetrain.

Mohd, Hassan and Aziz, (2015) designed an eV MATLAB model in which, by simulating torque and speed conditions; the energy flow, and performance of the drive were obtained.

Kiyakli and Solmaz, (2018) designed an eV model on MATLAB and concluded that his model consumed 16 kWh of energy per 100 KM, for a vehicle with a maximum range less than 180.

The existing literature on chemistries of secondary batteries, AIS standards on electric Vehicle, dynamics of electric Vehicle, drive cycle in consideration with Indian conditions, financial implications of transition from conventional to electric vehicle; and simulation analysis of designed and modelled electric Vehicle are studied and the corresponding shortcomings are stated in the subsequent chapters.

3. DESCRIPTION OF BROAD AREA

The EV's consist of major four components battery, electrical components (power converter, controllers) motor and Ancillaries (Steering braking and drives) Figure 4 describe one such EV with its major components. The performance of an electric vehicle thus depends on the optimized performance of all these subcomponents. Energy utilization of EV has to be economically done since its all parts are dependent on energy supplied by batteries. These batteries has limited capacity of storing and providing power to the EV and its subsystems. Specific energy, specific power, energy efficiency, energy density, typical voltages, Amp-hour efficiency, commercial availability, cost, self-discharge rates, operating temperatures, number of life cycles, recharge rates, State-of-Charge, State-of-Health, and other battery parameters all play a key role in the designing of EV's commercial viability and safety.

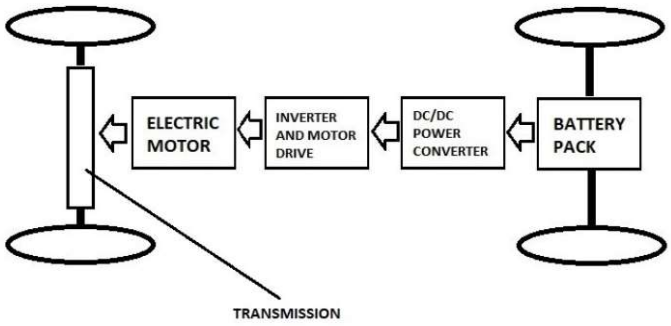


Figure 4: Architecture of Electric vehicle

The energy is stored in energy storage systems as direct current, whereas for operation and running, the vehicle motors requires alternating current or controlled current / voltages. Power Converter control these parameters at the time of running, climbing and braking. Power Converter also regulates the current and voltage ripples, and Electro -Magnetic Interference (EMI), which ultimately manipulate the final performance of an electric vehicle drive. Electrical parts of vehicle utilize AC / DC power source which are supplied through inverters as per the need. Rectifier works just opposite of Inverter, it converts AC into DC for energy to be stored in the battery.

Motors have an upper edge over the engines as they can generate torque very quickly, and accurately. According to the utility motors can be broadly classified as Direct Current Brushed Motor, Direct Current Brushless Motor, Induction Motor, Switched Reluctance Motor and Synchronous Motor. These motors have different performance characteristics.

Battery pack is a system in which we store electric charge in the form of chemical energy. It comprises of all rechargeable and non-rechargeable batteries. The life and safety of batteries can be enhanced with Battery Management System (BMS), which can control battery's charge and discharge process by controlling various parameters like State of Charge (SoC), State of Health (SoH), operating temperature, Depth of Discharge, etc. In the process of adoption electric vehicle technology, Auto sectors will have to go through a drastic change in terms of costs associated in transition, vehicle parameters, energy, cost of ownership, and infrastructure.

Hence the study of different parameters and their influence on the performance of EV and as a whole on the Auto Industry is of great importance that needs to be examined critically.

4. RESEARCH GAP FROM LITERATURE REVIEW

Transition from Internal Combustion Engine operated vehicles to Electric Motor operated vehicles is a technological revolution. It not only requires self-public adoption, but also an industrial regime change.

The following are the shortcomings found in the literature review:

a. A lot of research is undergoing on different battery chemistries and new battery material combination are developed but their application in Indian context is yet to be examined.
b. Not much research is made on financial cost analysis to completely shift to EV based mobility from convention fuel-based mobility.
c. The area of electric mobility has evolved recently. EV standards are in the preliminary stages of formation / under scrutiny by different certifying agencies. These standards has to be relooked with Indian perspective.
d. Although lots of research models has been done on vehicle dynamics but more studies are required to be done taking into account the Indian condition.
e. New literature with respect to usage of EV driving pattern, road grades with respect to Indian conditions are to be developed.
f. Before the vehicle comes on the road a lot of simulation has to be done for maintaining the safety and commercial viability of the designed product. A very less literature is available in this domain.

5. OBJECTIVES OF THE STUDY

The work described in this research plan includes an exploration of the fundamentals of EV components performance. Following tentative objectives are identified to accomplish the stated work:

i. To analyze the available battery chemistries for EV application with Indian perspective.
ii. To analyze financial impact of India's transition to electric mobility.
iii. To analyze Automotive Industry Standards (AIS) for Electric Power Train Vehicles
iv. To analyze and investigate EV dynamics with respect to Indian driving conditions.
v. To analyze the Indian Drive Cycle (IDC) with EV perspective.
vi. To perform simulation analysis of Electric Vehicle for enhanced performance.

6. PROPOSED RESEARCH METHADOLOGY

After going through the literature review on EV performance parameters it was found that very less work is reported on using of battery chemistry with Indian perspective. The different parameters such as energy density and power play a decisive role while selecting a battery for EV application All the battery chemistries will be analysed and suitable battery chemistry that fits Indian needs based on selected parameters will be recommended in phase 1.

The automotive (AIS) for electric power train are developed by ARAI. No literature is available on its applicability and analysis. These standards will be analysed in light of the tested standards available for IC Engines. The observed shortcomings will be analysed for complied solutions in this second phase

In the third phase analysis of EV vehicle dynamics will be done for improved vehicle performance. During this phase some studies on heat dissipation rates when the battery is charged / discharged at a very fast pace will be made.

A drive cycle is standardised in order to test and compare different vehicles. Each vehicle type (two-wheeler / small car / bus) may have its own drive-cycle Each city / town may have its own drive-cycle. An Electric vehicle will be analysed with the help of drive cycle in the fourth phase.

A lot of investment has to be made for transition from conventional fuel based mobility towards Electric mobility a financial impact analysis for India for this transition will be made during fifth phase

During the final phase, simulation analysis of an electric vehicle for enhanced performance will be done.

The complete process is explained with the help of figure 5

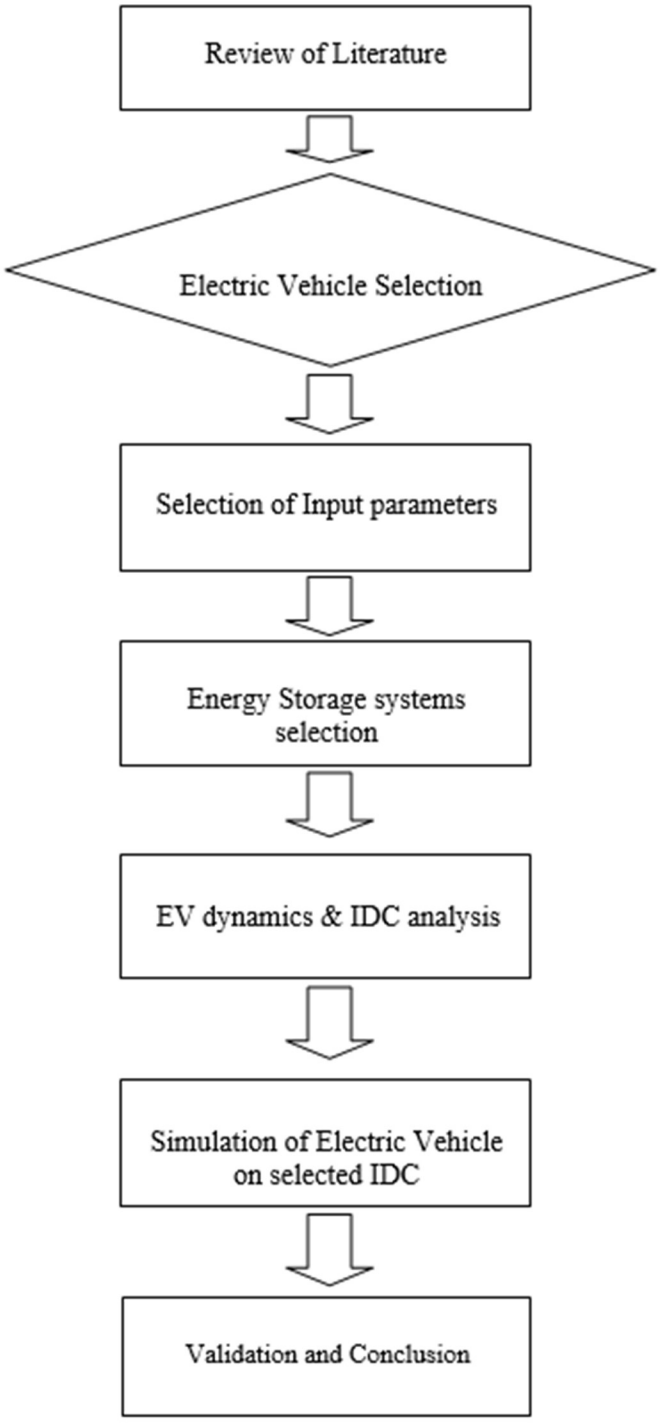

Review of Literature
Electric Vehicle Selection
Selection of Input parameters
Energy Storage systems selection
EV dynamics & IDC analysis
Simulation of Electric Vehicle on selected IDC
Validation and Conclusion

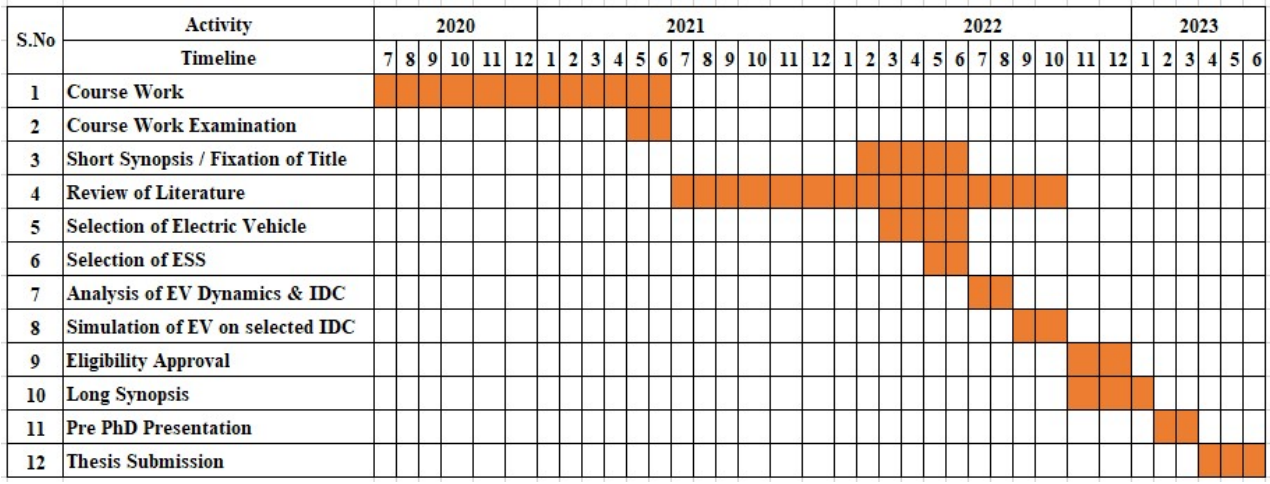
Figure 5. Proposed work flow diagram

7. EXPECTED OUTCOME OF THE RESEARCH

The proposed research focusses on parameters that influences the performance of EVs. The different parameters that influence the range are battery chemistry, type of drive train, EV dynamics and Drive Cycle. The research will help in better understanding of vehicle dynamics parameters i.e rolling, aerodynamic and gradient resistance foe energy requirement in EVs. The research will submit result that after analyzing the available battery chemistries for EV application with Indian perspective. It will evaluate Automotive Industry Standards (AIS) for Electric Power Train Vehicles for practical application and implementation of standards in new design. There have been many safety issues emerged in the EVs in the recent times. Findings of these safety issues will be shared with OEMs for improved product design. Results of analysis of EVs with modified drive cycle will be analyzed and shared with EV manufactures for incorporation of the suggested changes. Financial analysis of India's Transition to electric Mobility will be made and its implication on the automotive sector will be studied the copy of the same will be shared with the policy makers for planning. Simulation analysis of EV for enhanced performance will be made and findings shared with EV manufacturers for implementation in the future designs.

8. PROPOSED WORK PLAN AND SCHEDULING

Timeline for the major activities planned are provided in figure 6.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Activity
Timeline
2020
2021
2022
2023
7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6
1 Course Work
2 Course Work Examination
3 Short Synopsis / Fixation of Title
4 Review of Literature
5 Selection of Electric Vehicle
6 Selection of ESS
7 Analysis of EV Dynamics & IDC
8 Simulation of EV on selected IDC
9 Eligibility Approval
10 Long Synopsis
11 Pre PhD Presentation
12 Thesis Submission

Figure 6: Time lines

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ANALYSIS OF ELECTRIC VEHICLES FOR IMPROVED VEHICLE PERFORMANCE AND ASSOCIATED COST

SHORT SYNOPSIS

by

VARUN MALIK

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20/Ph.D/043
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ABSTRACT

The humans are becoming more and more dependent on the technology which enhance energy consumption from fuels, as a result, pollution and global warming are increasing, which is posing a great threat to the environment. For about three decades, government authorities have been trying to control pollution levels by framing emission standards for mobility Industry. Govt agencies are also continuous and timely making changes in the Bharat Standards for reducing emission levels to zero by technology enhancement. But with this continuous amendment in the policies relating to pollution there is still a risk of depletion of non-renewable fossil fuels.

The fossil fuels are not only getting exhausted, but also emits numerous forms of pollutants in the environment while being used in vehicles. To mitigate this problem the best solution that serves for protection of environment and also on the other hand, ensures the safeguard of existing natural fossil fuels is the use of vehicles with electrified powertrain. Such vehicles may or may not include the use of fossil fuels. These electric vehicles have a number of advantages as compared to the popular conventional fuel cars like low Noise-Vibration and

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